Remote sensing properties of graupel and hail storms over China and the United States from the Tropical Rainfall Measuring Mission

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Data

- The station hail reports in China during 1998-2013 are compiled based on two qualified datasets from the China Meteorological Administration (CMA), including hail occurrence time.
- Hail reports in U. S. came from the *Storm Data* of the National Climatic Data Center (NCDC)
- ***The China data is mostly graupel and small hail (1-10 mm) at fixed observing sites. The U.S. data is mostly larger hail reported by the general public.***
- The TRMM Precipitation Feature (PF) (Liu et al., 2008) is utilized to collocate the hail reports and study hail PFs properties.

Collocation Process

- The PFs possibly associated with hail are searched within one degree and one hour from the PF's centroid location and observation time.
- One hail report to one PF relationship. **1)** If multiple PFs are found within one degree and one hour of a hail report, the PF with the coldest minimum 37 GHz PCT is selected as the hail PF. **2)** When one PF is collocated with multiple hail reports, the hail report with the largest hail diameter and the nearest distance from the PF centroid.
- Definition of non-hail PFs. 1) in U. S., PFs that are in the south-central and southeast (30.5º–36.0ºN, 105.0º–80.5ºW) and not collocated with hail reports; 2) in China, PFs that are within 1 degree from weather stations and not collocated with hail reports.
- A threshold of 2000 m topography is used to distinguish high elevation and low elevation hail reports and PFs in this study. Cold seasons from December to February are excluded.

Table 1. Collocated hail numbers and all hail reports in different hail size intervals in China and United States south of 36° N.

Diameter (mm)	China				U.S.			
	High elevation (≥2000 m)		Low elevation (<2000m)		High elevation (≥2000 m)		Low elevation (<2000m)	
	All	Collocated	All	Collocated	All	Collocated	All	Collocated
<5	4318	445	199	17	0	0	0	0
5-9	1409	180	362	40	0	0	10	2
10-29	189	17	154	12	532	39	45123	4677
30-49	15	3	23	1	202	6	13668	1472
50-79	0	0	6	0	51	0	2917	38
>=80	0	0	0	0	6	0	333	41

Results

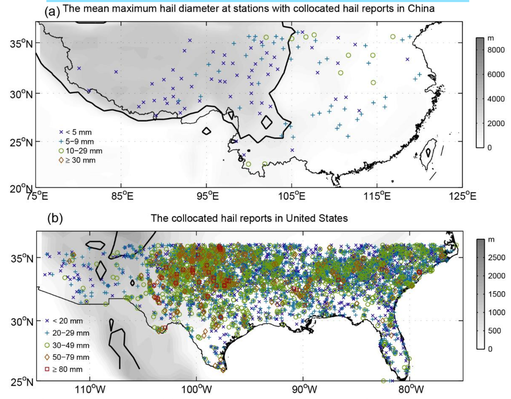


Fig. 1. (a) Locations of hail reports collocated with TRMM Precipitation Features in (a) China and (b) United States.

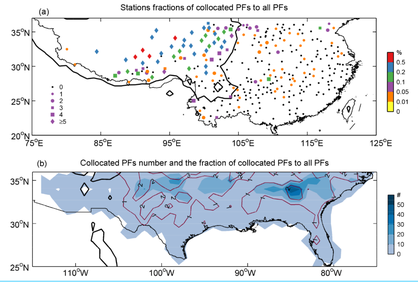


Fig. 2. The number of graupel and hail PFs, and the percentage relative to all PFs. (a) China. (b). United States

In China, hail reports mostly include diameters of 1-10mm and occur over Tibet Plateau. In China, the fraction of PFs collocated with hail reports is higher in high elevation region. This fraction reaches 3% in the plains of the U. S.

Hail PF V.S. Non-hail PFs

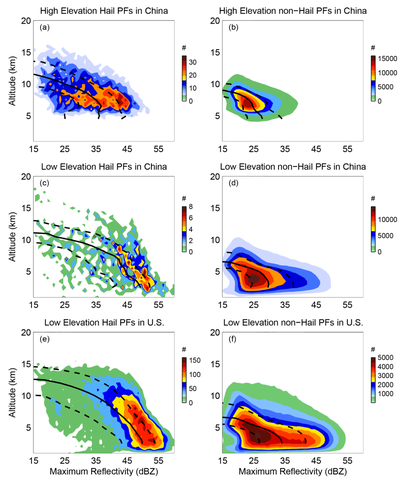


Fig. 3. Two dimensional histogram of maximum radar reflectivity profiles. The three lines are reflectivity at 25th, 50th, and 75th percentiles at each level.

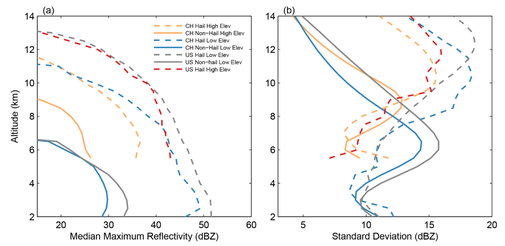


Fig. 4. Median maximum reflectivity profiles of **hail (dashed lines)** and **non-hail (solid lines)** precipitation features (a) and corresponding standard deviation profiles (b).

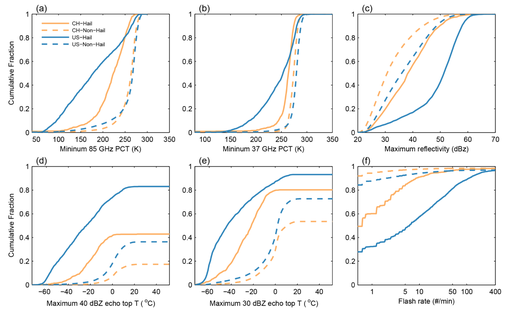


Fig. 5. The cumulative fractions of minimum 85 GHz PCT (a), minimum 37 GHz PCT (b), maximum reflectivity of MAXDBZ profiles (c), maximum 40 dBZ echo top temperature (d), maximum 30 dBZ echo top temperature (e), and lightning flash rate (f) of **Hail (solid)** and **Non-hail (dashed)** Precipitation Features (PFs).

Properties of storms with different hail sizes

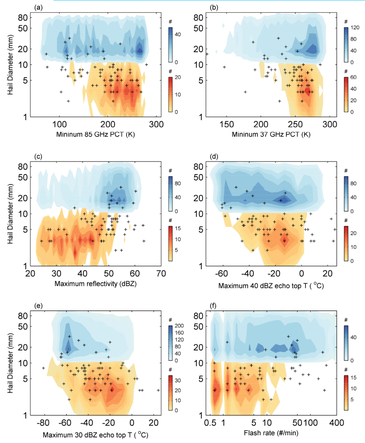
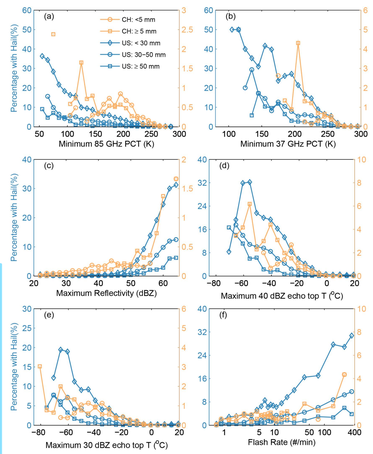


Fig. 6. Two-dimensional histograms of properties of hail precipitation features against hail sizes. The scattered plus signs are the hail PFs at low elevation (<2000 m) in China.

The relationships between TRMM observations and different sizes are constructed by taking advantage of different hail reporting methods in the two countries. Low elevation hail reports in China are found overlapped with the U.S. distribution.

Fig. 7. Percentage of Hail Precipitation Features (PF) relative to all PF. As the percentages of hail PFs in China are much smaller than those in U.S., different vertical coordinates are utilized in each subplot.



Distributions are consistent with the results of Cecil et al. (2009). For certain hail size, the percentage distribution have peaks, e.g. TMAXHT30 have maximum P around -40° C for small hail (<5mm) in China

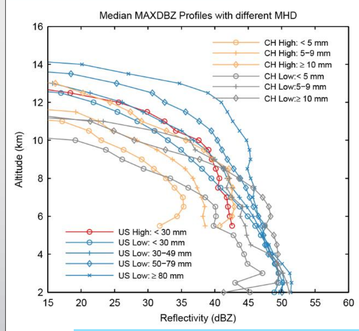


Fig. 8. Median maximum reflectivity profiles of hail Precipitation Features with different maximum hail diameter (MHD).

The larger the hail size, the stronger the maximum reflectivity and reflectivity above 6km are. High-Elev PFs have weaker maximum reflectivity.

Summary

- The hailstorms reported in the U.S., dominated by large hail, are generally stronger than those storms with small hail sizes in China, with higher radar reflectivity, higher lightning flash rate, and lower passive microwave brightness temperatures.
- The remote sensing properties of hailstorms with a full spectra of hail sizes are examined for the first time. In the overlapped hail size range, the systems over China and U.S. have close radar reflectivity and passive microwave TB properties.
- The maximum reflectivity profiles of storms show stronger reflectivity as the hail size increases, especially at levels above 6 km for storms with larger hail sizes.

Reference

Ni, X, C. Liu, Q. Zhang and D. Cecil, 2016. Properties of hail storms over China and United States from Tropical Rainfall Measuring Mission, JGR-Atmospheres (Accepted).